

27
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ACUTE AFFECTIONS PRODUCED BY EXPOSURE TO HEAT.

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THERE are two distinct diseases—or, more correctly, conditions—of the human body which are produced by exposure to heat, and which have a certain similarity in their symptoms, but are very different in their immediate pathology and require directly opposite methods of treatment. Although their individuality was pointed out as long ago as 1851 by the late D. F. Condie of this city,¹ yet they have been frequently confounded by writers upon the subject, and the terms heat-exhaustion and sunstroke have not rarely been used as strictly synonymous. In the present article it is proposed to consider them as separate affections under the respective names of heat-exhaustion and thermic fever.

Heat-Exhaustion.

Any one who has been long exposed to a high temperature under circumstances requiring physical exertion must have noticed the feeling of general weakness and relaxation which results. Thus far reaches our every-day experience, but cases in which acute symptoms are severe enough to cause alarm occur, although somewhat infrequently. The attack may come on slowly, but may be as abrupt as that of true sunstroke, and the severest cases may happen in those who have been in robust health as well as in the weak and feeble. The mind is usually clear, the pulse rapid and feeble, the surface cool, the voice very weak, muscular strength greatly lessened, and the feeling of exhaustion extreme. If this condition be intensified, syncope may be developed with its usual symptoms. In all this there is nothing peculiar and little that is necessary to notice here; but there is a form of heat-exhaustion in which the heart does not seem to suffer principally, but in which there is collapse with palsy of the vaso-motor system, great fall of the bodily temperature, and marked general nervous symptoms. At the International Exhibition of 1876 a very powerful man, whilst working in an intensely hot, confined space, fell down without giving warning, and was brought into the hospital. He was in a state of restless, delirious unconsciousness, incessantly muttering to himself, and when shaken and shouted at responding only by a momentary grunt. The pulse was rapid, fluttering and feeble. The

¹ Amer. Journ. Med. Sci., Jan., 1852.

surface was covered with a very heavy sweat and exceedingly cold. The muscular relaxation was extreme. The facies was that of collapse, and the temperature, as taken in the mouth, 95.25° F.

The PATHOLOGY of heat-exhaustion is best discussed in conjunction with that of thermic fever, and will therefore be for the present postponed.

The TREATMENT of heat-exhaustion is a very obvious one. The indications are to stimulate the circulation and warm the body by external heat with an energy proportionate to the severity of the attack. In mild cases the exhibition of a whiskey punch or similar beverage may suffice, but in severer attacks alcohol acts too slowly and is not capable of filling all the indications. It may re-excite the flagging heart, but it is probably not a vaso-motor stimulant, and if given too freely may even increase the vaso-motor depression. Digitalis is an excellent stimulant of the heart, and probably also of the vessels. It acts, however, comparatively slowly even when hypodermically injected, but in severe cases it should always be employed. The tincture is the most eligible preparation, and when injected under the skin in doses of fifteen drops causes no local irritation. Ammonia would be a very valuable remedy did not its use offer so many difficulties of administration: injected into the cellular tissue, it causes great pain and usually sloughing, and its intravenous use is by no means always easy. As a vaso-motor stimulant atropia is an excellent remedy, and, as it has also a very powerful influence in arresting the secretion from the skin and in raising the animal temperature, it should produce very good results in the peculiar form of collapse under consideration.

When the bodily temperature is below normal the most important measure of treatment is the use of the hot bath: the water should be from 100° to 120° F.—*i. e.* as hot as can be borne—and the whole body should be immersed in it until the mouth temperature becomes normal.

Thermic Fever.

SYNOMYS.—Coup de soleil, Sunstroke, Heat apoplexy, Heat asphyxia, Heat fever, Sun fever, Thermohaëmia, Erethismus tropicus, Insolation.

The immediate cause of thermic fever is always exposure to excessive heat in some form. As the body can cool itself much more readily in a dry than in a moist atmosphere, it is able to resist the influence of a dry, overheated air much better than when there is also moisture. It is for this reason that sunstroke is so much more infrequent upon the high table-lands of Abyssinia or in the dry belt of our Texan prairies than in the lowlands of India or upon our own seacoast. For the same reason it is especially prone to attack indoor workers in confined, moist factories, and especially in laundries and sugar-refineries. At one time it was thought that exposure to the direct rays of the sun was the chief cause of the disease, but there is now abundant clinical testimony to the fact that such exposure is in no sense necessary. Without occupying space in giving detailed references, it suffices, as an illustration of the fact that the most complete darkness is no protection, to allude to the epidemic upon the French man-of-war *Duquesne*, as recorded by M. Boudin, in which a

hundred cases of sunstroke occurred in a short time, most of them at night when the men were lying in their bunks. Bonniman¹ says: "By far the greater number of cases that yearly occur in India are of men who have not been exposed to the sun. It is not unusual for men to go to bed in apparent health, and to be seized during the night; and patients in hospitals who have been confined to bed for days previously are frequently the subjects of attack."

Although the immediate cause of the attack is excessive heat, there are certain conditions which act as predisposing causes by lessening the power of the system to resist the heat, or, in accordance with the theory of sunstroke which I believe established, by so weakening the inhibitory heat-centre that it is readily exhausted. The chief of these predisposing causes are race, excessive bodily fatigue, and intemperance. It is true that males are much more frequently affected than females; thus, in an epidemic occurring in St. Louis, Missouri, in 1878, there were 115 deaths in males and 39 in females. This is due, however, not to one sex being predisposed to the attacks, but to the habitually greater exposure of males than of females to heat. The much greater frequency of sunstroke in the laboring than in the upper classes has similar explanation.

Those races which are least accustomed to a tropical climate are most apt to be attacked; thus, both in this country and in India, Europeans suffer far more than do the natives. No race is, however, absolutely exempt. Even the negro and the Hindoo inhabitant of tropical India are occasionally prostrated.

The general experience in the United States shows that habitual excess of alcohol very strongly predisposes to attack, but some of those who have had widest experience in India are inclined to deny this. It has been especially noted in India that persistent bodily fatigue greatly weakens the resisting power of the European. As an instance of this may be cited the case of the Forty-third regiment of the line during the Sepoy rebellion, as recorded by its surgeon, Barclay. It had made a most extraordinary march of over eleven hundred miles, chiefly through the lowlands of India, and at the hottest season of the year. This march was continuous, with the exception of a few brief halts. No cases of sunstroke occurred until nine hundred and sixty-nine miles had been traversed and the men had become thoroughly exhausted and even markedly emaciated. Shortly after this the regiment rested some eight days, and then started again, arriving soon in a narrow ravine in the Bissramgunge Ghat, with precipitous walls nearly a mile in height. During the day the thermometer in the tents ranged from 115° to 127°, and on one occasion was noted 105° at midnight. The number of cases of insolation now became very great, and, although most of them recovered, 2 officers and 11 men were lost in the four days during which the regiment remained encamped. The air became cooler as the command emerged from the hills, yet 7 more fatal cases occurred in three days.

SYMPTOMS.—Under the name of ardent continued fever, or febris continua communis, has been described in India an affection which may be considered as representing a mild form of thermic fever. In C. Morehead's clinical work *On the Diseases of India* the following account of the symptoms is given: "The attack is generally sudden, often without

¹ *Edinburgh Med. Journ.*, vol. xiv. p. 1029, 1864.

much chilliness. The face becomes flushed; there are giddiness and much headache, intolerance of light and sound. The heat of skin is great; the pulse frequent, full, and firm. There is pain of limbs and of loins. The respiration is anxious. There is a sense of oppression at the epigastrium, with nausea and frequent vomiting of bilious matters. The bowels are sometimes confined; at others vitiated discharges take place. The tongue is white, often with florid edges. The urine is scanty and high-colored. If the excitement continues unabated, the headache increases, and is often accompanied with delirium. If symptoms such as these persist for from forty-eight to sixty hours, then the febrile phenomena may subside, the skin may become cold, and there will be risk of death from exhaustion and sudden collapse. In most cases the cerebral disturbance is greater in degree, and in these death may take place at an earlier period in the way of coma."

Until very recently the existence within the United States of this class of cases has not been recognized. But in a very able article in the *Therapeutic Gazette* of March 16, 1885, John Guiteras shows that the so-called typhoid fever of Key West is the disease described by Morehead.

In the *Philadelphia Medical Times*, vol. v. p. 664, C. Comegys calls attention to the cases of entero-colitis which are so abundant in the young children of our cities during the hot months. The immediate enormous rise of the mortality-rate among children which always accompanies a marked rise of temperature during July or August indicates very strongly that excessive heat is the chief factor in the production of the disorder. The symptoms may be summed up as high fever, dry tongue and mouth, rapid pulse and respiration, intense thirst, vomiting, purging of greenish, watery, fecal or serous matters with undigested particles of food, and more or less pronounced evidences of cerebral disturbance, such as insomnia, headache, contracted pupils, delirium, and finally coma. In some cases the bodily temperature rises before death to a point comparable with that it reaches in sunstroke of the adult. As pointed out first by Comegys, these cases are almost uniformly relieved by cold water used either, as Comegys himself employs it, in the form of cold affusions practised until the temperature of the child becomes normal, or, as, according to my own experience, is preferable, simple cold baths administered every two to three hours, with just sufficient vigor to produce the desired effect.

Thermic fever in the adult and in this latitude is usually first seen by the physician after the stage of insensibility has been reached. In many cases this condition comes on with great suddenness, but in other instances there are distinct prodromata, such as inaptitude and disinclination to exertion, vertigo, headache, confusion of ideas, great oppression or distress at the praecordia or epigastrium, and disturbances of the special senses. Swift has noticed a peculiar chromatopsia, the sufferer seeing everything of a uniform color, in most cases blue or purple, but in others red, green, or even white, and W. H. Kesteven¹ has reported a case in which a man, after exposure to an excessively hot sun, was seized with severe headache, saw everything red or green, and had for some days a distinctly impaired color-sense.

At one period I saw a large number of advanced cases of sunstroke in

¹ *Trans. Clin. Soc. of London*, 1882, xv. 101.

the hospital, and the symptoms were quite constant. Total insensibility was always present, with, in rare instances, delirium of the talkative form, and still more rarely the capability of being roused by shaking or shouting. The breathing was always affected, sometimes rapid, sometimes deep and labored, often stertorous, and not rarely accompanied by the rattle of mucus in the trachea. The face was usually suffused, sometimes, with the whole surface, deeply cyanosed. The conjunctiva was often injected, the pupils various, sometimes dilated, sometimes nearly normal, sometimes contracted. The skin was always intensely hot, and generally, but not always, dry; when not dry it was bathed in a profuse perspiration. The intense burning heat of the skin, both as felt by the hand and measured by the thermometer, was one of the most marked features of the cases. The degree of heat reached during life was, in my cases, mostly 108°-109° F., but it sometimes reaches 112° F. The pulse was always exceedingly rapid, and early in the disease often not wanting in force and volume; later it became irregular, intermittent, and thready. The motor nervous system was profoundly affected: subsultus tendinum was a very common symptom; great restlessness was also very often present, and sometimes partial spasms or even violent general convulsions. The latter were at times epileptiform, occurring spontaneously, or they were tetanoid and excited by the slightest irritation. Sometimes the motor system suffered paralysis, the patient moving neither hand nor foot.

This extreme motor relaxation, which in my observation is rare, seems to have been very common in the epidemic described by Barelay,¹ as he states that in a large proportion of the cases, from the commencement of the attack until its termination in death, the patient never moved a limb or even an eyelid. Petechiae and ecchymoses, the evidences of broken-down blood, were present in some of my cases, and there was in one or two instances a fetid hemorrhagic exudation from the nostrils during life. A symptom which has almost escaped the attention of authors was a peculiar odor, which was most marked in patients who had involuntary passages, but was very distinct from any fecal odor. The stools emitted it very strongly, but so did the skin and breath. It was so distinctive as to render possible the recognition of a case by the sense of smell alone. The discharges from the bowels were liquid and very often involuntary. None of my cases passed urine whilst under observation.

It is plain that the symptoms of *coup de soleil*, as usually seen, may be summed up as those of intense fever, accompanied by profound nervous disturbance (as manifested by insensibility with or without delirium, and by motor symptoms, such as convulsions or paralysis), by arrest of glandular action, and by changes in the blood. In this ordinary form of sun-stroke death takes place by asphyxia or by a slow spontaneous failure of both respiration and cardiac action. It very rarely occurs in less than half an hour after the first decided symptoms, and usually is postponed for a much longer period.

There is a form of *coup de soleil* in which death results almost at once, and probably always by cardiac arrest, and to which the name of the cardiac variety may well be given. It is very rarely, if ever, met with in civil life, and among soldiers is especially seen during battle or at other

¹ *Madras Quarterly Journal*, 1860, 364.

times when great exertion is being made. These cases will be more fully discussed in a later portion of this article.

POST-MORTEM CHANGES.—Owing to the excessive heat of the body, putrefactive changes occur very rapidly after death from sunstroke, and various described lesions, especially of the heart, have been undoubtedly the result of post-mortem changes. Later observers have confirmed my original observation, that if the body be opened directly after death the left ventricle will be found firmly contracted, though the right heart and the pulmonary arteries, with their branches, are gorged with dark fluid blood. In my cases the lungs did not present at all the appearance of congestion of their minute capillaries, but when they were cut the blood poured from them abundantly, seemingly from their larger vessels. Not only do the lungs suffer from venous congestion, but the whole body also. The blood appears to leave, as it were, the arterial system and collect in the venous trunks. The arterial coats are often stained red, apparently by the broken-down red corpuscles of the blood.

There can be no doubt that the blood suffers in sunstroke very similarly to what it does in low fevers. Its coagulability is impaired, but not always destroyed, and it is possible that in the very rapid cases it may not be decidedly affected. After death it appears as a dark, often thin, sometimes grumous fluid, whose reaction is very feebly alkaline, or, as I have seen it, even decidedly acid. Levick¹ appears to assert that the blood-discs, as seen by him under the microscope, were shrivelled and crenated, and showed very slight tendency to adhere in rouleaux. In several of my cases the blood was carefully examined by the microscope, but nothing abnormal was found. The extravasations of blood which have been found by K. Köster in various parts of the nervous system are probably of the nature of petechiae, the results of the altered blood-crasis, and not due to any especial affection of the nerve-centres.

THEORY OF THE DISEASE.—The theories which have been brought forward as explanatory of the phenomena of sunstroke are so various that it would be impossible in the limits of this paper to discuss them. It does seem, however, proper to give a very brief historical sketch of the development of our present knowledge of the subject. In 1854, H. S. Swift² said that the disease is "now generally admitted to be merely exhaustion produced by fatigue," although he recognized the existence of an "apoplexy produced by insulation." The cases which Swift so well describes as those of heat-exhaustion were true instances of thermic fever. The physicians of the Pennsylvania Hospital, especially Gerhard, early called attention to the resemblance of sunstroke to a fever, but it was not until January, 1859, that their views found expression in print in the paper published by James J. Levick in the *American Journal of Medicine*. This observer tabulated the post-mortem appearances of typhus fever and of sunstroke in contrast, calling attention also to the similarity of symptoms during life. In 1863, H. C. Wood³ claimed distinctly that sunstroke is a fever due to the development of a poison in the blood, and gave to the disease the name of thermic fever. To R. Cresson Stiles is due the credit of having first proven⁴ the possibility of producing in animals a sunstroke with symptoms and path-

¹ *Pennsylvania Hospital Reports*, 1868, 373. ² *New York Med. Journ.*, vol. xiii. p. 53.

³ *Amer. Journ. Med. Sci.*, October. ⁴ *Boston Med. and Surg. Journ.*, June, 1864, p. 349.

ological changes similar to those which occur in man. He also came to the conclusion that the symptoms are the results of the direct action of heat, especially upon the muscular system. He says: "The dilatation of the capillaries is explicable by the direct effect of the heated blood upon the muscular fibres of the arteries and the arterioles. The cerebral symptoms and the full and forcible pulse may also be due to this dilatation." George B. Wood, in the sixth edition of his *Practice of Medicine* (Philadelphia, 1866), wrote an elaborate article upon the disease, giving it the name of heat fever, and affirming that it "is, I believe, strictly an idiopathic fever." He further asserts: "In heat fever all the organs, the brain, heart, lungs, stomach, kidneys, etc., are excessively stimulated by the great heat, and all exhibit disorder and at length depression of their functions." The article of George B. Wood was not based upon experimental researches, but upon a very philosophic rendering of the clinical phenomena, and was a carrying out of the ideas which had permeated the medical teaching of the Pennsylvania Hospital.

About 1869, Eulenberg and Vohl¹ advanced the theory that death from sunstroke is the result of the sudden liberation of gases in the blood; and Weikard affirmed that the death is due to the increase of the coagulability of the blood and consequent formation of clots in the vessels, being in this supported by Richardson of London.² Contrasting with these in its being really an important contribution is the article of Vallin:³ its chief merit is the conception of the idea of the local heating of isolated parts of the body, and the devising of a plan for carrying the idea into effect. The experiments of Vallin did not themselves prove very much, and led him to the erroneous conclusion, first, that the death in sunstroke is the result either of a coagulation of the left ventricle or else of a disturbance of the innervation of the heart by an action of the heat upon the nerve-centres in the base of the brain; second, that these two forms of death correspond to sthenic and asthenic varieties of insolation—varieties which, I believe, have no proper existence.

The first experiments of Claude Bernard upon the action of external heat were given in a lecture upon muscular respiration on May 3, 1864, published in his *Leçons sur les Propriétés des Tissus vivants* (Paris, 1866). They were merely incidental to another research, and simply showed that when a warm-blooded animal was exposed to heat it died, the death being, according to the observations of Bernard, the result of cadaveric rigidity suddenly attacking the heart. The more elaborate researches of Claude Bernard upon the effect of exposure of animals to external heat, so far as I have knowledge, were not published in detail until after the nature of sunstroke was determined, although the lectures were delivered in the years 1871 and 1872; they may be found reported in full in his *Leçons sur la Chaleur animale, sur les Effets de la Chaleur, et sur la Fièvre* (Paris, 1876).

It is proper also to state here that some of the physicians of India had previous to this time more or less imperfectly recognized the relation of sunstroke to fever, but, I believe, none of them distinctly postulated the theory.

The above historical sketch shows that by many authors the relation

¹ *Virchow's Archiv*, t. Ixii.

² *St. Bartholomew's Reports*, vol. vii.

³ *Archives générales de Médecine*, Février, 1870.

of sunstroke to fever had been more or less dimly perceived, and that George B. Wood had very clearly stated the true nature of the affection, in that it was simply the result of the direct action of heat. Such statement, however, not resting upon proof, had not been accepted: it was also wanting in detail, and where such details were attempted the surmises were not always correct. Under these circumstances my researches, made in 1870 and 1871, and first published in 1872, led to the complete understanding of the affection.

The space allotted to me in the present volume will not allow of any detailed account of my experiments, but I shall quote from my summing up of the results obtained by them. It was shown that sunstroke may be produced in animals as readily as in man either by natural or artificial heat; that the symptoms are similar to those seen in man; that death takes place ordinarily by asphyxia; that after death the characteristic lesions are alteration of the blood and rigidity of the heart, with immediate or quickly-appearing post-mortem rigidity of the general muscular system; that this rigidity of the heart comes on in most cases after, not before, death, and is a result, not cause, of death; that post-mortem rigidity is dependent upon coagulation of myosin, and that the rigidity of the heart is of similar origin, coagulation of the muscle-plasma occurring almost instantaneously at 115° F., a degree almost attained in sunstroke; that when a muscle has been in great activity immediately before death, myosin coagulates at a much lower temperature, and that the cases of sudden cardiac death occurring in battle among the East Indian English troops were no doubt due to the coagulation of the heart's myosin; that heating the brain of a mammal produces sudden insensibility, with or without convulsions, at a temperature of 108° F., and death when a temperature of 113° is reached; that this effect of the local application of heat is not due to induced congestion, but is the result of the direct action of the heat upon the cerebrum, and that consequently the nerve-centres are as perniciously affected by high temperature as the muscles are; that the nerve-trunks bear a temperature of 125° F. without their conducting power being immediately affected; that whilst the general symptoms induced by heating the brain of a rabbit are very different from those of sunstroke, the nervous symptoms are exactly similar; that the life of the blood is not destroyed by any temperature reached in sunstroke, the amoeboid movements of the white blood-cells and the absorption power of the red disks not being injured; that the amount of oxygen of the blood is greatly lessened, as the result of gradual asphyxia combined with abnormal consumption of oxygen; that there is no reason for believing that capillary thrombi are common in sunstroke; that there is no specific poison developed in the blood; that the deterioration of the vital fluid is due to the rapid tissue-changes induced by the fever and the more or less complete arrest of excretion; that such deterioration is secondary to the nervous symptoms, not primary; that if the heat be withdrawn before it has produced permanent injury to the nervous system, blood, or other tissues, the convulsions and unconsciousness are immediately relieved and the animal recovers.

As a postulate from these facts and deductions, I think it follows that the nature of sunstroke is that of a fever; or, in other words, that *coup de soleil* is a fever, not dependent upon blood-poisoning, but upon heat.

It is of course possible that the external heat causes the fever, simply by preventing the body from throwing off the caloric which it is constantly forming. The extreme suddenness of the onset, however, indicates that in at least many cases there is a sudden outburst, as it were, in the production of heat in the body. This indication becomes more important when it is remembered that in cerebral rheumatism, so called, there is often an equally sudden attack of symptoms plainly the result of a sudden production of animal heat.

In an elaborate research¹ I showed the truth of Setschenow's theory, that there is in the pons a centre whose function it is to inhibit the production of animal heat, and that in the medulla a centre (probably the vaso-motor centre) which regulates the dissipation of the bodily heat; and that fever is due to disturbance of these centres, so that more heat is produced than normal, and proportionately less heat thrown off. Let it be supposed that a man is placed in such an atmosphere that he is unable to get rid of the heat which his body is forming. The temperature of his body will slowly rise, and he may suffer from a gradual thermic fever. If early or late in this condition the inhibitory heat-centre becomes exhausted by the effort which it has been making to control the formation of heat, or becomes paralyzed by the direct action of the excessive temperature already reached, then suddenly all tissues will begin to form heat with the utmost rapidity, the bodily temperature will rise with a bound, and the man drop over with some one of the forms of *coup de soleil*.

Under this view of the case the widespread popular belief, that protecting the back of the head and upper neck from the direct rays of the sun is useful against sunstroke, gains in significance, because it is possible that local heating of the parts spoken of may occur and aid in the production of inhibitory paralysis.

If this theory of thermic fever be correct, heat-exhaustion with lowered temperature probably represents a sudden vaso-motor palsy—*i. e.* a condition in which the exhausting effects of the heat paralyzes not the inhibitory heat-centre, but the vaso-motor centres in the medulla, since my experiments have shown that vaso-motor palsy increases enormously the loss of animal heat and diminishes its production.

In most cases of sunstroke death comes on gradually by arrest of respiration, such arrest being without doubt due to direct paralysis of the respiratory centres by the excess of heat. Allusion has already been made to the cases of sudden death by cardiac arrest, which have especially been seen in India, almost always during a march or during a battle. "As an example of it may be cited the account given by a witness to Parkes, and incorporated in his work on hygiene,² of an occurrence during the first Chinese war. The Ninety-eighth regiment was marching on a very hot day, and the surgeon who was with the rear-guard stated to Parkes that the men fell suddenly on their faces as though struck with lightning, and on his running up and turning them over many of them were already dead. Maclean, who was present at this occurrence, confirms the account given by Parkes, but states that it was at the attack on Chiang-Kiang-Foo. The men were thickly clothed, with tight accoutrements and tight, rigid stocks, and were charging up a very steep hill. A great

¹ *Fever*, Smithsonian Institute, 188-.

² *Pract. Hygiene*, 2d ed., p. 360.

number of them were stricken down, and fifteen died instantly, falling on their faces and giving merely a few convulsive gasps."

It has been shown that excessive exercise so alters the condition of the myosin of muscle as to cause it to coagulate much more readily than normal. During battle the amount of muscular effort that is made is enormous, and hence it is that men are so often found stiffened in the attitude in which they were struck by the bullet, instantaneous death being followed by equally instantaneous post-mortem rigidity. The description that has been given by Parkes and Maclean of the circumstances in which the sudden deaths just described occurred shows that the heart-muscles must have been strained to their utmost limit. The men were making violent exercise going up hill, so that the heart must have been in exceedingly active exertion, increased by the impediment to the circulation afforded by the tight accoutrements, and under these circumstances the victims probably died instantly because the heart-muscle suddenly set itself from life into the stiffness of death.

The DIAGNOSIS of thermic fever is usually made with great readiness. In distinguishing between it and heat-exhaustion the temperature of the body is the guide. In apoplexy with high temperature it is possible that a little embarrassment might be experienced, but in apoplexy the high temperature follows the nervous symptoms after a distinct interval, but in thermic fever it precedes the unconsciousness. An apoplexy may develop during a sunstroke, but such occurrence is rare. T. S.—, now under my care, has had frequently repeated attacks of local convulsions affecting two fingers of the right hand, and one general epileptic attack whilst under observation. He dates his illness to a sunstroke on July 7, 1885, and O. D. Robinson of Georgetown, Delaware, writes me that the attack was undoubtedly true thermic fever, and that the movements of the fingers came on whilst the patient was recovering consciousness. It is probable, therefore, that there was a rupture of a small vessel in the brain-cortex during the sunstroke. The appearance of local convulsions or of localized paralysis during a sunstroke would be good ground for believing that either a clot or a thrombus had formed.

PROPHYLAXIS AND TREATMENT.—The prophylaxis of sunstroke is so evident in its nature that it may be dismissed in a few words. When exposure to heat is imperative the bodily health should be maintained by avoidance of alcoholic, sexual, or other excesses, and, as far as possible, of great bodily or mental fatigue; the diet should be almost purely farinaceous, and the glandular apparatus of the bowels, kidneys, and skin kept in an active state by the use of fruit, water in abundance, and mild salines if necessary. Many persons have a very strong prejudice against the drinking of cold water during exposure to heat; and it is conceivable that large draughts of intensely cold ice-water may do harm by suddenly chilling the stomach; but when the water is taken in small quantities at short intervals, by its action in reducing the general temperature, but especially by its rendering free perspiration more easy, it must exert a most favorable influence. The addition of claret or some other local stimulant to the water is often of great service when there is a tendency to gastric or intestinal depression.

In the mild cases of continued thermic fever the basis of the treatment should be the use of the cold bath. The plan adopted by Guiteras at Key

West was to wrap the patient in a dry sheet, lift him into a tub of water, having the temperature between 80° and 85°, and then rapidly cool this water by means of ice. The time of the immersion lasted from fifty to fifty-five minutes, it being regulated by the thermometer in the mouth of the patient. The patient was then lifted out upon a blanket, the skin partially dried, and the body covered. Guiteras found great advantage by giving a moderate dose of whiskey and thirty minims of the tincture of digitalis twenty minutes before the bath. He states that it is very important to avoid currents of air blowing upon the patient and to have the bath given in a small warm room. The result of the bath was invariably a lowering of the temperature, a reduction of the rate of pulse and respiration, and a refreshing sleep. After the second bath the course of the temperature seemed permanently influenced for the better. It was never necessary to give more than two baths in the twenty-four hours, but in some cases they had to be used for many days.

In the severe acute form of thermic fever it is essential that the bodily temperature be reduced at once, and no time should be lost waiting for a physician. As soon as the patient falls he should be carried into the shade with the least possible delay, his clothing removed, and cold affusions over the chest and body be practised. This must not be done timidly or grudgingly, but most freely. In many cases the best resort will be the neighboring pump. In the large cities of the United States during the hot weather hospital ambulances should be furnished with a medical attendant and with ice and antipyrin, so that when a sunstroke patient is reached he may be immediately stripped underneath the cover of the ambulance and remedial measures applied during his passage to the hospital. I believe many lives are now sacrificed by the loss of critical moments in the interval between the finding of the patient and his reaching the hospital ward.

If circumstances favor, instead of the cold affusions, rubbing with ice may be practised. The patient should be stripped and the whole body freely rubbed with large masses of ice. When practicable, a still better plan is to place the patient in the cold bath (50° F.) The employment of enemata of ice-water, as originally suggested by Parkes, may sometimes be opportune.

In using these various measures it must always be borne in mind that the indication is the reduction of temperature: if the means employed do not accomplish this, they do no good.

Relaxation of the pupil is said to be "the first symptom that shows the good of the cold affusion;"¹ but as, in my experience, the pupil frequently has not been contracted, reliance cannot be placed upon this, and the thermometer in the mouth or the rectum affords the only proper guide as to the effect of the treatment.

It must be borne in mind, however, that the cold douche, cold bathing, etc. are powerful remedies, and are capable, if used too long, of doing harm. In my experiments upon animals I have seen the temperature, when reduced by the cold bath after sunstroke, continue to fall, after the animal had been taken out of the water, until it was many degrees below normal.

In the cases which have come under my own observation after the use

¹ Aitken, *Practice of Medicine*, vol. ii. p. 394.

of the cold bath but little treatment has been required. If, however, the period of insensibility has lasted too long, there may be no return to consciousness, even though the bodily temperature be reduced to the norm. Under such circumstances the case is almost hopeless, and I know of no treatment other than that of meeting the symptoms as they arise, excepting that a large blister should, in my opinion, be applied to the whole of the shaved surface of the scalp.

After the temperature has been reduced, and even after consciousness has returned, there is sometimes a great tendency to a fresh rise of temperature, and consequent relapse. This tendency may be met by wrappings in wet sheets, and, if necessary, by a recourse to the more powerful measures for reduction of temperature which have been already cited. It can be to some extent controlled by the use of quinine, ten grains of which may be given hypodermically. During the heated term of the summer of 1885 antipyrin has been used both in New York¹ and in Philadelphia² with asserted most excellent results; and the testimony is so strong that I think it should always be employed as an aid to, not as a substitute for, the direct extraction of the bodily heat. It should be given hypodermically, as soon as the patient is found, in doses of from fifteen to thirty grains.

In cases complicated with repeated severe convulsions, hypodermic injections of one-quarter of a grain of morphia have been very frequently given in the Pennsylvania Hospital, with excellent results. In such patients the use of anaesthetics to facilitate the giving of cold baths would be very proper, but so long as the temperature is high nothing should be allowed to substitute the external cold.

Severe headache and other evidences of cerebral inflammation, manifesting themselves directly after the recovery of consciousness, should be met by local or even general bleeding, blistering, the use of arterial sedatives, mercurials, etc.; or, in other words, by the treatment of cerebral inflammation from other causes adapted to the exigencies of the individual case.

Formerly, venesection was largely practised in sunstroke, with occasional excellent effects, but with, on the whole, very bad results. As free bleeding lowers temperature markedly, it can be readily understood that in some cases it might bring about a return of consciousness and yet be a very improper remedy. If in any instance sthenic apoplectic symptoms persist after the lowering of the bodily temperature by the bath, venesection should be carefully considered. There are cases of sunstroke in which the high temperature irritates the brain or its membranes into an acute congestion or inflammation. These complications are especially prone to occur when the high temperature has been allowed to continue for a long time. A case of this character, in which the autopsy revealed proof of the presence of an acute meningitis, may be found on p. 121 of my book on *Thermic Fever*. When, then, the patient has a tendency to excessive headache and continuous fever, bleeding may become an essential remedy, not for the cure of thermic fever, but of the cerebral inflammation which has been produced by that fever. The case of S. Weir Mitchell is in point. In his early manhood he had a sunstroke, and when conscious-

¹ B. F. Westbrook, *New York Med. Journal*, July 25, 1883.

² Orville Horwitz, *Trans. College of Physicians of Philada.*, Oct., 1885.

ness began to return "the first sensation was that of an intense, agonizing headache, and the next was the perception of his father—J. K. Mitchell—and Mütter discussing the possibility of his recovery. As soon as he could speak, he said, 'Bleed me.' His father, coming to the bed, shook his head, but the son repeated, 'Bleed me.' He persisted in simply repeating this until they thought him delirious; but at last he mustered strength to say, 'I am not delirious, but have a frightful headache: if you don't bleed me I will die.' By this time his pulse had become full and bounding, and finally he sat up and was bled. Ten or fifteen ounces were taken without avail; but as more blood flowed the headache vanished, to be succeeded by a feeling of most delightful languor and rest from pain. Between twenty-five and thirty ounces were taken, and afterward recovery was a very simple matter."

That Mitchell by the bleeding was saved from meningitis appears almost certain, but it is most probable that if he had been primarily immersed in a cold bath no bleeding would have been required.

SEQUELÆ.—Almost all persons who have had a *coup de soleil* suffer from after-effects. In the mildest form these are inability to bear exposure to heat without cerebral distress or pain, with more or less marked failure of general vigor, dyspeptic symptoms, and other indications of disturbed innervation. In other cases the symptoms are more decided. Pain in the head is usually prominent: it may be almost constant for months, but is always subject to exacerbations. It sometimes seems to fill the whole cranium, but not rarely is fixed to one spot; and I have seen it associated with pain in the upper cervical spine and decided stiffness of the muscles of the neck. With it may be vertigo, decided failure of memory and of the power of fixing the attention, with excessive irritability. When the symptoms approach this point in severity, there is usually marked lowering of the general health, loss of strength, possibly some emaciation, and the peculiar invalid look produced by chronic disease.

Epileptic convulsions occasionally follow a sunstroke, but, at least in my experience, are always associated with more constant evidences of cerebral disease.

A pathognomonic symptom in the sequelæ of sunstroke is the effect of heat. The glare and heat of summer are the most trying, but usually artificial heat is not well borne. It is very common for headache and severe general distress to be produced by going into a warm room even in the winter months. Where cerebral symptoms are affirmed to be the result of a sunstroke, if there be no excessive susceptibility to heat the alleged sunstroke has almost certainly been an attack of some other nature; and on several occasions I have been enabled to determine that a supposed epileptic attack or a fall followed by unconsciousness from violence was really a sunstroke by noting the extreme susceptibility to heat. The symptom I believe to be a diagnostic one.

The lesion in these cases is usually chronic meningitis, though it is possible that in some instances the gray matter rather than the membrane of the brain may be affected, and in severe cases the gray matter is of course more or less compromised. In one case occurring in the care of S. Weir Mitchell, and in one in my own practice in which death occurred from extraneous causes, severe chronic meningitis was found at the autopsy.

The TREATMENT of these cases is that of chronic meningitis, with the added precautions against exposure to heat. In any severe case change of habitation to a cool climate during the hot period of the year is essential: twenty-four hours' exposure may undo all the good achieved by months of careful treatment.

It is hardly proper here to enter into a detailed discussion of the remedial measures to be employed in this as in the other forms of non-specific chronic meningitis. Local bleedings, the use of counter-irritation, especially by the actual cautery, the internal administration of mercurials and of iodide of potassium in small continued doses, with abstinence from brain-work and the regulation of the habits of life, constitute an array of measures which will no doubt be fully discussed by the author of the article upon Chronic Meningitis.

Provided the patient can be entirely controlled, the PROGNOSIS in these cases is not so bad as at first it appears to be. As an instance of a remarkable recovery I condense from my notebook the case of T. W. H—, aged 49, who came under my care with a history that two years previously he had been seized during a hot day in the summer with a very violent headache, which continued for five weeks, confining him to bed, and was associated, as he said, with fever, but no other symptoms. This attack had been diagnosed by several physicians variously, but as I found that he was excessively affected by any exposure to the sun, was always worse in summer, and that in winter his symptoms were extremely exaggerated even by such heat in a room as is agreeable to many persons, I concluded that the original attack had really been one of thermic fever. He had lost about forty pounds in weight; his memory had become so bad for recent events that he could not call to mind things which had transpired one or two hours previously. Sight had failed much, and there was double vision. He suffered from almost incessant dull headache and excessive general wretchedness; the optic discs were slightly swollen, and one of the margins obscured. There was no albuminuria, and the dyspeptic symptoms were so bad that the man had been treated for months for dyspepsia. Nine months of treatment sufficed to restore this patient almost to his original health. The treatment consisted essentially in the alternate administration of minute doses of calomel and of iodide of potassium—in the meeting of various minor symptoms as they arose, but chiefly in the persistent, merciless use of counter-irritation at the nape of the neck. The actual cautery was applied every one or two weeks, and antimonial ointment freely used on the burnt surface.